BMDE 610: Functional Neuroimaging Fusion

COURSE OUTLINE

**Lectures**
Class time: Friday 8h30 – 11h30
Class room: Duff 321

*All course materials, slides will be posted online on Mycourses*

**Instructor**
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**Prerequisite:**
ECSE 305, MATH 223 or equivalent. The main requisites consist in being familiar with some notion of linear algebra (matrix multiplication, inversion) and statistics (Gaussian distribution, Bayes’ rules)

**Course description**

**Learning Outcomes**
To gain sufficient knowledge regarding the complementaries and limitations of functional exploration techniques of brain activity:
(i) electrophysiology: measuring neuronal bio-electrical activity with Electro- or Magneto-EncephaloGraphy (EEG vs MEG), (ii) hemodynamic processes: measuring indirectly the blood response to an activated brain region using functional Magnetic Resonance Imaging (fMRI) or Near Infra Red Spectroscopy (NIRS)
To understand the concepts of ill-posed inverse problem and multimodal fusion
To be able to critically assess most studies published in this field.
To be able to interpret EEG/MEG source localization results, fMRI results, NIRS results
To be able to chose a particular method/software when having to analyse such data
To be able to assess whether a new methodology was appropriately validated.
Evaluation Procedure

(1) Mid-term exam: March 1st 2024 (Subject to change), 8h30:9h30 (30%)
   - Understanding of important concepts
   - Interpreting source localization results

(2) Assignment 1: March 22nd 2024 (15%):
   - Implementing and testing source localization using Brainstorm software

(3) Participation (attendance): 5%

(4) Final Project: report (25%) oral presentation (25%):
   - Detailed analysis of an article or a particular application of neuroimaging data
     fusion, with specific emphasis on validation methodology. The objective of the
     project is to present in details, the added value of using data fusion in a specific
     application context. A clear and detailed understanding of the proposed
     methodology is expected

   Oral presentation (25%): April 12th 2024
   Report (25%) – (8 pages, Times New Roman, 12pts): April 19th 2024

McGill policy statements

“McGill University values academic integrity. Therefore, all students must understand the
meaning and consequences of cheating, plagiarism and other academic offences under the
Code of Student Conduct and Disciplinary Procedures” (see
www.mcgill.ca/students/srr/honest/ for more information). (approved by Senate on 29
January 2003)

“In accord with McGill University’s Charter of Students’ Rights, students in this course
have the right to submit in English or in French any written work that is to be graded.”
(approved by Senate on 21 January 2009 - see also the section in this document on
Assignments and evaluation.)
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Proposed Outline (subject to small modifications to be updated on Mycourses)

<table>
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<tr>
<th>Week</th>
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| Jan 5<sup>th</sup> | W1: 8h30-10h: Introduction  
W1: 10h-11h30: Basic principles in MEG/EEG, in fMRI/NIRS |
| Jan 12<sup>th</sup> | W2: 8h30-9h30: Important concepts: Multimodal fusion  
W2: 9h30-10h30: Important concepts: Validation Methodology  
W2: 10h30-11h30: Equivalent current dipoles |
| Jan 19<sup>th</sup> | W3: 8h30-11h30: Generative models (forward pb): EEG/MEG (N. V Ellenrieder) |
| Jan 26<sup>th</sup> | W4: 8h30-10h: Dipole scanning approaches (MUSIC, Beamformer)  
W4: 10h-11h30: Distributed models 1: Min Norm, LORETA, L1 |
| Feb 2<sup>nd</sup> | W5: 8h30-10h: Distributed models 2: anatomical MRI constraints  
W5: 10h-11h30: Distributed models 3: Hierarchical Bayesian Models |
| Feb 9<sup>th</sup> | W6: 8h30-10h00: Distributed models 4: MEM, Fusion EEG/MEG  
W6: 10h00-11h30: Brainstorm software training |
| Feb 16<sup>th</sup> | W7: 8h30-10h: Time-Frequency analysis of EEG/MEG (J.M. Lina)  
W7: 10h-11h30: Time-Frequency based source localization (J.M.Lina) |
| Feb 23<sup>rd</sup> | W8: 8h30-10h: fMRI analysis: Study design, GLM, Bayesian Models,  
W8: 10h-11h30: Simultaneous EEG/fMRI in epilepsy (J. Gotman) |
| March 1<sup>st</sup> | **W9: 8h30-9h30: Midterm exam**  
W9: 9h30-11h30: Atlas of intracranial EEG data (B. Frauscher) |
| March 8<sup>th</sup> | W10: No class, reading week |
| March 15<sup>th</sup> | W11: 8h30-10h: fMRI analysis: Multiple comparison  
W11: 10h-11h30: Exploring oscillatory brain networks with MEG and intracranial EEG (K. Jerbi) |
| March 22<sup>nd</sup> | W12: 8h30-10h: Computational modeling involving neuronal, hemodynamic and metabolic activity (H. Benali)  
W12: 10h-11h30: fMRI analysis: functional connectivity (B. Bernhardt) |
| March 29<sup>th</sup> | No class Easter Friday |
| April 5<sup>th</sup> | W13: 8h30-10h: NIRS analysis: GLM, deconvolution, inverse problem  
W13: 10h-11h30: Comparative / Constrained / Symmetrical Fusion |
| April 12<sup>th</sup> | **W14: 8h30-11h30: Final projects / Oral presentations** |